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(10) PAUL F. TWITCHELL*

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A conference ~~was held in London from 21 to 23 October 1980 to~~ discussed the relationship of climate to the world's offshore energy resources. The conference focused upon such areas as the impact of oil resources upon the economies of developed and developing countries, the importance of providing climatic data in sufficient time to meet users' needs, and the hazards and financial burdens associated with the development of offshore oil reserves. One of the important achievements of the conference was the →

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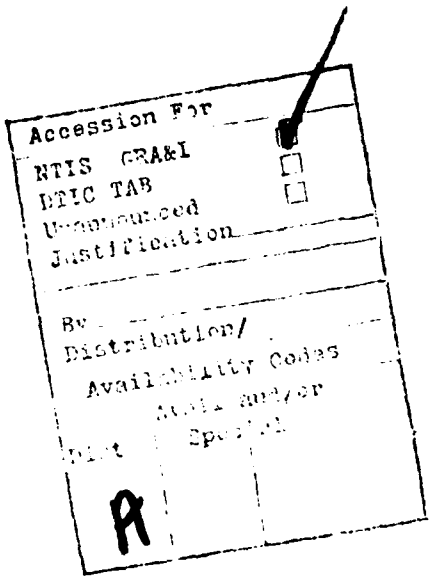
establishment of better communications between the users of environmental data and those charged with producing predictions.



CLIMATE AND OFFSHORE ENERGY RESOURCES

A distinguished group of government officials, scientists, engineers, and industrialists met in London from 21-23 October 1980, to discuss the relationship of climate to the world's offshore energy resources. The site of the meeting was The Royal Society's elegant headquarters on Carlton House Terrace overlooking the Mall and Saint James Park. The meeting was jointly arranged by the Society of Underwater Technology, The Royal Meteorology Society, and The American Meteorology Society.

Prof. Raymond Hide, representing the Royal Society, opened the meeting expressing his own scientific interest in the topic. He may be remembered by many for advancing the discipline of geophysical fluid dynamics in the 1960s when he was at the Massachusetts Institute of Technology. Hide introduced the chairman of the opening session, Dr. P. Goldsmith (Royal Society). One of Goldsmith's contributions to the atmospheric sciences was in the measurement of water vapor (dew point) at very low levels.

The Honorable Roy Jenkins, president of the Commission of the European communities, who was the next speaker, observed that the problem of human management of the earth's resources is becoming an important dimension in political, economic, and social thought. Jenkins noted that these topics were addressed in the reports on the Summit meeting in Tokyo in 1979 and again at the Summit meeting in Venice in 1980. He reported that the community is responding to these topics with a 5-year climatic research program designed to focus on 2 main areas of concern: learning more about the mechanisms of climatic systems, and gaining a better understanding of the impact of climatic change on human resources. He continued by saying "I believe that this reduction of uncertainties about climate in all its aspects should have high priority. One of the most interesting of those areas of uncertainty is the thermal exchange between air and ocean, and here, offshore energy development could have significance."

Jenkins was followed by Dr. Michael Davies who read the paper of Dr. L. Williams (Director General, Energy, Commission of the European Communities, Brussels). Williams' scholarly report contained many facts often overlooked in the US. The paper opened with a review of the world energy situation, noting the 1973 oil crisis and its precursors in 1967 and 1956. According to Williams, these experiences taught a number of lessons:

(1) Oil is not a limitless resource.
(2) Industrialized nations have become dependent on oil.
(3) Oil often is used wastefully.
(4) Developing countries may never reach full development without access to oil.
(5) Increased use of fossil fuels may result in undesirable environmental side effects.

The European Community has reduced its dependence upon imported oil to 50% in 1979 and has as its goal the achievement of less than 40% dependence by 1990. The hope was expressed that the introduction of the cleanest

and most efficient source of energy, nuclear power, with almost 2000 reactor-years of remarkably safe operation, would increase in the community from its 3% share today to 12% by 1990. Expanding on Jenkins' comments regarding the European Community's 5-year research program on climate, Davies reported that a budget of approximately 11 million dollars had been approved for the purpose. During the discussion following this paper on climate program, it was stated that only 1% of the Community's research budget is allocated for energy (including climate) while in comparison, approximately 57% is directed toward agriculture.

The next speaker, Dr. Gordon A. McKay (Director, Climatological Applications Branch, Canadian Climate Center, Toronto) shifted the scene from Europe to North America. His talk included many facts, such as the $20 billion loss to the US gross national product as a result of the cold winter of 1976-1977. McKay concluded his presentation with the comment that every effort should be made to foster and improve communication between scientists and decision-makers so that users' needs for climatic or real-time environmental data can be identified before financial or environmental losses materialize.

Prof. Bert Bolin (Univ. of Stockholm) is one of the few recognized scientists who has examined the effects of pollutants in the environment. His presentation in the opening session mentioned many atmospheric constituents, but he particularly emphasized "changes" in CO_2. He suggested that the atmospheric conditions may be better now than they were half a century ago due to man's efforts to reduce emissions. The only reliable CO_2 measurements indicate that there has been an increase of 21 parts per million during the last 23 years. The emissions from the burning of fossil fuels in the same period should have produced twice the measured amount. In addition, there should be a net transfer of carbon to the atmosphere due to deforestation and increased agriculture. Bolin also believes that most modelers do not consider the role of the oceans, including the bottom sediments. The ability of the ocean to exchange carbon is a function of temperature, which in effect, maintains an equilibrium. According to Bolin, the most serious deficiencies in contemporary models are the crude representation of clouds, cloud dynamics, and cloud radiation, and the inadequate treatment of oceans, particularly intermediate and deep ocean water. Bolin concluded that there has been no detectable change in climate due to the increase attributed to atmospheric CO_2 since the industrial revolution. He believes that CO_2 is not a problem today and he considers it likely that by the time it could become a problem (possibly several centuries from now) man will be using something other than fossil fuels for locomotion and general energy supply.

The second session of the conference, chaired by Sir James Lighthill FRS (Provost, University College, London), focused upon studies of the atmosphere and oceans.

The first presentation entitled, "The Oceans and Ocean Currents: Their Influence on Climate," was delivered by Prof. Reginal Newall (Dept. of Meteorology, Massachusetts Inst. of Technology [MIT]). Part of the paper dealt with the work of Newall and his associate using empirical orthogonal

function analysis of non-seasonal values of zonal mean sea surface temperatures, evaluated separately for each ocean. Apparently, all known usable sea surface temperature data were used. The significant result was the determination that the most important non-seasonal signal was Sir Gilbert Walker's oscillation, first reported in 1923, and named by Walker as the Southern Oscillation. Newall's group concluded that the Southern Oscillation is the most important air-sea interaction signal other than that imposed by the ice age. There is still no satisfactory physical explanation of the Walker oscillation.

Dr. Adrian Gill (Dept. of Applied Mathematics, Univ. of Cambridge) continued the ocean theme with a review of ocean models. Ocean modeling is not as advanced as atmospheric modeling and is far more difficult to verify. However, Gill presented an optimistic paper indicating that oceanographers are making progress.

The next paper, by Prof. Verner Suomi (Univ. of Wisconsin) was unquestionably the best one presented by the scientific community. He used film clips from Hide's rotating tank experiments and time-lapse movies of earth's cloud motion imagery taken from a geosynchronous satellite. Suomi also used film clips of cloud motion on Venus, and very recent Jupiter data. These data were utilized to describe the Earth's atmospheric circulation and the circulation of other planetary atmospheres. He included new findings presented the previous week by Prof. Erik Mollo-Christensen (MIT) on how to infer ocean current information from polar orbiting satellite imagery. Suomi's slides on the wind derived from cloud motion and the most recent (the previous week's) atmospheric sounding data from a satellite just launched. All these data appeared to overwhelm the audience and a lively discussion followed. Suomi suggested schemes for using satellite data for offshore energy (oil) operations and proposed the development of a new system with two satellites specifically for the North Sea operations.

The third session of the conference, "Techniques of Prediction," was chaired by this reporter. The opening paper was presented by Dr. A. Winn Nielson, (Secretary-General, World Meteorological Organization, Geneva). Nielson presented an excellent paper. He was the first speaker at the conference to define the context in which climate should be simulated by models. The definition is: "Climate is the synthesis of weather over the whole of a period essentially long enough to establish its statistical ensemble properties and is largely independent of any instantaneous state." He continued by noting that a climate model should include interaction between atmosphere, ocean, land surface, and the cryosphere. The present models, according to Nielson, are limited and fall essentially into four categories: (1) globally averaged, (2) zonally averaged, (3) four-dimensional atmospheric, and (4) coupled atmospheric-oceanic. The demand for computer capability for the last two categories is high, and, again according to Nielson, all contemporary models are quite far from simulating the climate. Most models are deficient in accounting for changes in the ocean or ice-distribution. An example of a serious misapplication of models is evident in connection with the influence of CO_2 on climate. The models used do not incorporate the known role of the oceans and biosphere. Nielson said that results from such model studies are suspect. Also, for larger time scales models are

simplified, but in essence they become analogous to the large-scale turbulence problem for which there is no general theory. Nielson concluded that there is too much emphasis on the models which are elaborations of the earlier general circulation models for the atmosphere. In Nielson's judgement, these models do not treat the slow processes which apparently drive the climate, while other climate models not built on general circulation models are not very realistic. In the discussion following the presentation, Nielson commented on the potential of Prof. Klaus Hasselman's stochastic dynamic approach. In response to a question as to the merits of rotating-tank simulations, Nielson expressed the belief that such experiments constitute a viable alternative considering our inability to formulate an appropriate large-scale turbulence theory and the tremendous demand on computer time required to exercise large multidimensional models.

The second paper of the third session was presented by Dr. Brian Hoskins (Univ. of Reading). It was a natural follow-on to the opening paper. Hoskins described what a climate model should include. His concept includes the sun, the atmosphere, land, ocean, ice, and man. He continued by reporting on some of his recent work at the University of Washington with Dr. J.M. Wallace. They used 15 years of data and found, with a simple model, 5 dominant teleconnections; one of these appears to be related to the Southern Oscillation and to the cold winter of 1976-1977 in the US. Hoskins believes from his theoretical work that it is easier to produce significant anomalies in middle latitude weather by forcing from tropical regions than by a middle latitude forcing of some kind.

The final paper of the third session was presented by Mr. A. Gilchrist (Deputy Director, UK Meteorological Office). Gilchrist identified three categories of predictions: (1) deterministic, (2) probabilistic, (3) long term. Deterministic and probabilistic predictions are sensitive to initial conditions of the atmosphere, while long-term or climate prediction is often assumed to be less dependent on the present atmospheric state. Gilchrist focused on the potential of tailoring contemporary numerical models for climate predictions and claimed that the long-term effect of sea surface temperature anomalies was not significant in time periods of a season or more.

The fourth session of the conference was titled "The Next 100 Years" and was chaired by Mr. G. Williams (Director-General, UK Offshore Operators Association). Prof. Helmut E. Landsberg (Univ. of Maryland), who is the most distinguished climatologist in the US, lectured on recorded fluctuations of climate. In his scholarly address he noted that contemporary man tends to extrapolate from a spot variation and often categorizes what he perceives to be an anamoly as anthropogenic. He reviewed many of the cyclic theories and other hypotheses on climate change and concluded that for at least the next 10 to 20 years no observable change in climate can be expected. Landsberg was queried extensively by the media representatives, primarily Ms. B. Horsfield (British Broadcasting Corporation). Horsfield apparently was directly involved with the production of a television special on climate change. She had difficulties accepting Landsberg's assertions that Mt. St. Helen's did not cause England's cold summer, that CO_2 was not a serious

problem, and that the reported sea-level rises are insignificant. Prof. H.H. Lamb (East Anglia University), probably the world's most widely recognized climatologist, supported Landsberg with an eloquent statement from the floor on the dangers of extrapolating data.

Dr. B. Boville (Director, World Climate Program [WCP], World Meteorological Organization [WMO], Geneva), introduced the discussion of the WMO program by observing that in today's highly developed societies localized climatic variations can cause profound effects. For example, the recent Sahelian drought (1976) resulted in great misery and loss of life in an area that periodically suffers from drought. Traditionally, the people have migrated from the affected area (in Morocco) to better areas during such droughts. The 1956 drought was also severe, but hardship was minimized by migration. Unfortunately, in 1976 the same people were prevented (at gunpoint) from crossing newly established political boundaries. Boville reported that the WCP, which was formally established in May 1979, had begun to implement a World Climate Research Program (WCRP), a World Climate Applications Program (WCAP) and a World Climate Data Program (WCDP). He listed a series of meetings scheduled to formulate strategies for implementing the WCP. A focal point, the WCP office in Geneva, has already been established.

Dr. A. Nyberg (Past President, World Meteorological Organization) presented a paper in which he gave his estimates of the total resources of energy which are available or may become available to mankind. In this paper, Nyberg essentially reported his views on each of the known energy sources and potential sources.

Mr. G.L. Haskins (Chief Surveyor, Shell UK Exploration and Production) opened his talk, the last of the fourth session, with a comment on a proposed law of the sea which, if it is ratified, will open large and deep areas of the ocean for development under the terms of exclusive economic zones but will essentially close the areas extending 200 miles from national coastlines to international research. Haskins also outlined the impact of the environment on offshore operations, from surveying to delivery of the product to shore. He identified areas of research and development for fulfulling the offshore industry's requirements. They include remote monitoring of wave and surface currents by satellite or radar. Haskins said that there is a need for an operational system to work on understanding subsurface currents, and for development of real-time reliable means of transmitting measured data. He also said that we need to develop a better understanding of varying physical, chemical, and biographical characteristics of the water column so that significant problems in acoustic transmission can be assessed. In addition, Haskins mentioned the need for better understanding of chemical and biological factors that cause corrosion.

The last session was chaired by Mr. H. Houlder (President, Society of Underwater Technology). In the opening paper, Dr. J. Birks (Managing Director, British Petroleum [BP] Co. Ltd.) observed the path that ratio of reserves to production has been following for the past 40 years and said it is possible that the free world's oil production may level off by the year 2000. He believes that up to 40% of future discoveries of oil will be made

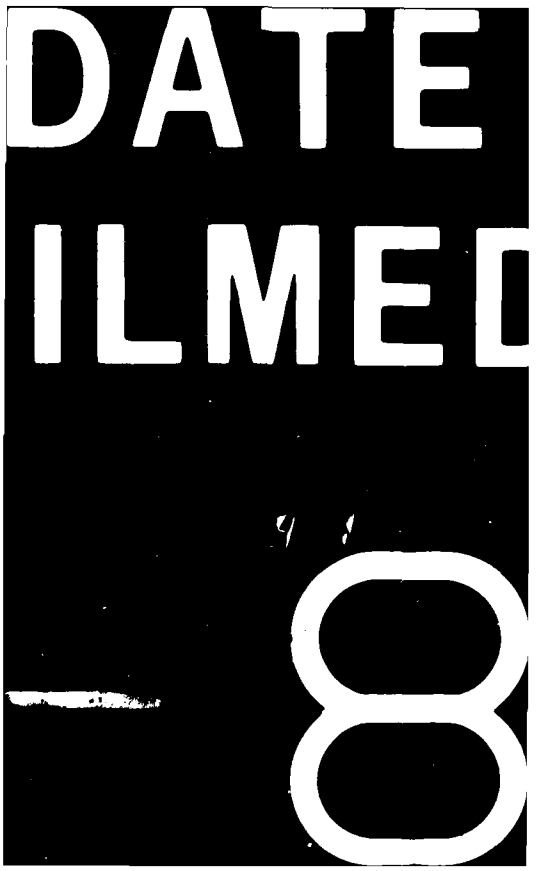
offshore and in deeper water, and that this will require significant improvements in underwater engineering technology. The major area of challenge is in field development and production rather than exploration. Birks mentioned two new types of platforms: semisubmersible production platforms, and BP's Single Well Oil Production System (SWOPS). This system will permit the transfer of oil from a well directly into a tanker equipped with self-contained gas/oil separators. Interestingly, the new areas of offshore exploration include Vietnam, the China Sea, and the region off the east coast of the USSR. Other potential areas, which apparently are receiving less attention at present, include Newfoundland and the Falkland Islands area. Birks stressed the effect of the environment on building and maintaining offshore oil rigs and delivering oil from offshore fields. For example, it takes 48 hours to pull a riser (the pipe that brings the oil up) to a s semisubmersible rig. During that time a swell not greater than 5 meters can be tolerated. He noted that in the Gulf of Mexico less than 10% of the waves exceed 2 meters, while in the North Sea area 75% of the waves are higher than 2 meters. The height of the so-called 100 year storm wave for the Gulf of Mexico in 250 meters of water is approximately 25 meters, while the height of the wave designed for in the North Sea is 35 meters. The cost of the larger and more rugged facilities required to withstand the more threatening environment is staggering: in the North Sea the cost of delivery of a barrel of oil has risen by a factor of 10 as the companies have moved into deeper water.

The last two papers of the conference addressed techniques for extracting energy from the natural environment. Dr. F.J.P. Clarke (Harwell Laboratory, UK) discussed tides, waves, and winds as sources of energy. Clarke presented detailed analyses of the cost effectiveness of exploiting tidal power. He described how the Severn Estuary in the UK and the Bay of Fundy in North America might be harnessed. His data indicate that at present energy costs these projects would be marginally cost effective. Clarke added that from a technological standpoint extracting energy from offshore winds and waves was even more difficult to accomplish and both must be shown to have better economic potential before being seriously considered.

The final speaker was Dr. John D. Ditmars (Argonne National Laboratory, US Dept. of Energy). Ditmars described the Ocean Thermal Energy Conversion (OTEC) technology, from the basic physical concept first described in the scientific literature about a century ago to the deployment of the pilot plant in progress during the conference. Although the overall efficiency of an OTEC electric power generating plant is only 3%, the attractiveness of such a plant is the fact that the fuel is the ocean water itself. The thermal gradients (20°C) required for an OTEC facility are often found near islands which normally import fuel for electric generation. Ditmars mentioned some special applications for which OTEC technology might be particularly useful. These included its employment as a power supplement for island communities and for energy-intensive industries such as those that reduce bauxite to aluminum. A floating plant to accomplish this end is now being studied.

The last session ended with a general discussion in which it was agreed that the goals of the conference had been met; specifically, lines of communi-

cation had been established between users of environmental data and those charged with producing predictions. The financial importance of weather and climate to offshore operators was clear, and the scientists and industrialists who participated in the meeting were also in agreement on the need to invest in scientific research programs and to improve predictions on all scales from a few minutes to climate time scales.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